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(71)(72) Applicant and Inventor: ELLIS, Frampton, E., III [US/US]; 2895 South Abingdon Street, Suite B-2, Arlington, VA 22206 (US).

(74) Agent: KANANEN, Ronald, P.; Marks Murase & White, 2001 L Street, N.W., Suite 750, Washington, DC 20036 (US).

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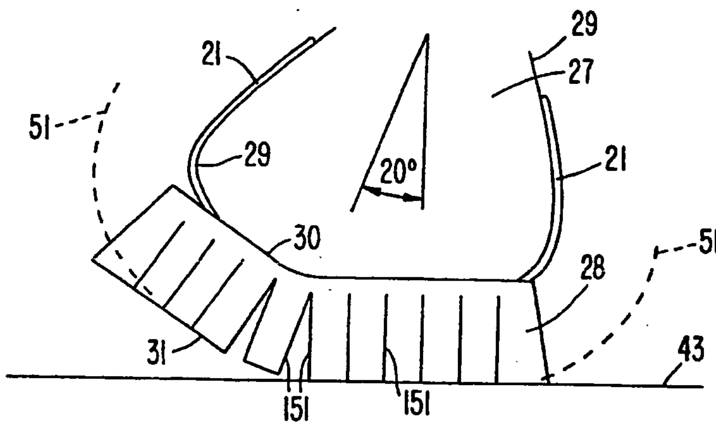
(54) Title: SHOE SOLE STRUCTURES WHICH ARE SIPED TO PROVIDE NATURAL DEFORMATION PARALLELING THE FOOT



(57) Abstract

A construction for a shoe, particularly an athletic shoe, which includes a sole (28) that conforms to the natural shape of the foot shoe, including the bottom and the sides, when that foot sole deforms naturally by flattening under load while walking or running. Deformation slits (151) or channels are introduced in the shoe sole along its long axis, and other axes, to provide it with flexibility roughly equivalent to that of the foot. The result is a shoe sole that accurately parallels the frontal plane deformation of the foot sole, which creates a stable base that is wide and flat even when tilted sideways in extreme pronation or supination motion. In marked contrast, conventional shoe soles are rigid and become highly unstable when tilted sideways because they are supported only by a thin bottom edge.

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SHOE SOLE STRUCTURES WHICH ARE SIPED TO PROVIDE NATURAL DEFORMATION PARALLELING THE FOOT

BACKGROUND OF THE INVENTION

This invention relates generally to the structure of shoes. More specifically, this invention relates to the structure of athletic shoes. Still more particularly, this invention relates to shoe soles that conform to the natural shape of the foot sole, including the bottom and the sides, when the foot sole deforms naturally during locomotion. Still more particularly, this invention relates to the use of deformation sipes such as slits or channels in the shoe sole to provide it with sufficient flexibility to parallel the frontal plane deformation of the foot sole, which creates a stable base that is wide and flat even when tilted sideways in natural pronation and supination motion.

By way of introduction, many conventional boat shoes are siped, a fairly archaic term derived from early automotive tire traction techniques. Siped shoe soles are provided with parallel slits or channels through portions of the shoe sole bottom, to increase traction for the otherwise typically smooth rubber sole bottom. This concept was originally introduced by Sperry with its old and famous "Topsider" boat shoe model, which incorporated U.S. Patents Nos. 2,124,986, 2,206,860, and 2,284,307.

The traction sipes in the form of slits or channels run perpendicular to the long axis of the shoe, since slipping is most typical along that long axis coincident to locomotion forwards or backwards. The parallel traction slits typically penetrate to a depth of about a third or slightly more of the boat shoe.

The applicant's invention is to use similar sipes such as slits or channels that, however, penetrate through most or even all of the shoe sole, to provide as much flexibility as possible to deform naturally, rather than to increase traction.

Moreover, the slits or channels of the applicant's invention are located on the opposite axis from those in conventional boat shoe soles.

Thus, it is an overall objective to provide the shoe sole with flexibility roughly equivalent to the foot sole. Such flexibility will allow the shoe sole to parallel the frontal plane deformation of the foot sole, which naturally creates a stable base that is wide and flat even when the foot is tilted sideways in normal pronation and supination. In complete contrast, conventional shoes soles are extremely rigid in the frontal plane and become highly unstable when tilted sideways on their very narrow bottom sole edge.

The inherent instability of existing shoes is caused by a conventional shoe sole that will not deform to provide as much contact with the ground as the foot does naturally. Both conventional heel counters and motion control devices increase the rigidity of the shoe sole and therefore increase the stability problem, creating an unnaturally high and unnecessary level of ankle sprains and chronic overuse injuries.

It is another objective of this invention to introduce additional slits or channels on different axes to provide shoe sole motion paralleling the natural deformation of the moving foot in other planes.

It is another objective of the invention to provide flexibility to a shoe sole even when the material of which it is composed is relatively firm to provide good support; without the invention, both firmness and flexibility would continue to be mutually exclusive and could not coexist in the same shoe sole.

The applicant has introduced into the art the concept of a theoretically ideal stability plane as a structural basis for shoe sole designs. That concept as implemented into shoes such as street shoes and athletic shoes is presented in pending U.S. applications Nos. 07/219,387, filed on July 15, 1988; 07/239,667, filed on September 2, 1988; and 07/400,714, filed on August 30,

1989, as well as in PCT Application No. PCT/US89/03076 filed on July 14, 1989. The purpose of the theoretically ideal stability plane as described in these applications was primarily to provide a neutral design that allows for natural foot and ankle biomechanics as close as possible to that between the foot and the ground, and to avoid the serious interference with natural foot and ankle biomechanics inherent in existing shoes.

This new invention is a modification of the inventions disclosed and claimed in the earlier application and develops the application of the concept of the theoretically ideal stability plane to other shoe structures.

Accordingly, it is a general object of this invention to elaborate upon the application of the principle of the theoretically ideal stability plane to other shoe structures.

These and other objects of the invention will become apparent from a detailed description of the invention which follows taken with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows, in frontal plane cross section at the heel portion of a shoe, the applicant's prior invention of a shoe sole with naturally contoured sides based on a theoretically ideal stability plane.

Fig. 2 shows, again in frontal plane cross section, the most general case of the applicant's prior invention, a fully contoured shoe sole that follows the natural contour of the bottom of the foot as well as its sides, also based on the theoretically ideal stability plane.

Fig. 3, as seen in Figs. 3A to 3C in frontal plane cross section at the heel, shows the applicant's prior invention for conventional shoes, a quadrant-sided shoe sole, based on a theoretically ideal stability plane.

Fig. 4 shows, in frontal plane cross section at the heel portion of a shoe, a conventional modern running shoe with rigid heel counter and reinforcing motion control device and a conventional shoe sole.

Fig. 5 shows, again in frontal plane cross section, the same shoe as Fig. 1 when tilted 20 degrees outward, at the normal limit of ankle inversion.

Fig. 6 shows, in frontal plane cross section at the heel, the human foot when tilted 20 degrees outward, at the normal limit of ankle inversion.

Fig. 7A shows, in frontal plane cross section at the heel portion, the applicant's new invention of a conventional shoe sole with deformation slits aligned in the vertical plane along the long axis of the shoe sole; and Figs. 7B-7E show close-up sections of the shoe sole to show various forms of slits and channels.

Fig. 8 is a view similar to Fig. 7, but with the shoe tilted 20 degrees outward, at the normal limit of ankle inversion, showing that the modified conventional shoe sole can deform in a manner paralleling the wearer's foot, providing a wide and stable base of support in the frontal plane.

Figs. 9A-9D are a series of views showing portions of cross sections similar preceding figures, wherein Fig. 9A shows the deformation slits applied to the applicant's prior quadrant sided invention, Fig. 9B show them applied to his prior naturally contoured sides invention, with additional slits on roughly the horizontal plane to aid natural deformation of the contoured side, and Figs. 9C and 9D show the slits applied to the applicant's invention of essential support elements.

Fig. 10 shows in frontal plane cross section at the heel a design in its undeformed state that deforms to the equivalent of the applicant's fully contoured prior invention, which conforms to the contour of the bottom of the foot, as well as the sides.

Fig. 11 shows a similar view of the Fig. 10 design on the wearer's unloaded foot, deforming easily to conform to its contours.

Fig. 12A is a view almost identical to Fig. 11 except that the deformation slits penetrate the shoe sole completely to maximize flexibility, and Fig. 12B show the same design when running, in 10 degrees of supination.

Fig. 13 shows several bottom views of the applicant's design in Figs. 13A to 13D for shoe soles showing sample patterns of deformation slits.

Fig. 14 shows several additional patterns in Figs. 14A to 14D of deformation slits to provide multiplanar flexibility.

Fig. 15 shows the principles of the preceding figures applied to the bottom sole layer only.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figs. 1, 2, and 3 show frontal plane cross sectional views of a shoe sole according to the applicant's prior inventions based on the theoretically ideal stability plane, taken at about the ankle joint to show the heel section of the shoe. In the figures, a foot 27 is positioned in a naturally contoured shoe having an upper 21 and a sole 28. The shoe sole normally contacts the ground 43 at about the lower central heel portion thereof, as shown in Fig. 4. The concept of the theoretically ideal stability plane, as developed in the prior applications as noted, defines the plane 51 in terms of a locus of points determined by the thickness(es) of the sole. The reference numerals are like those used in the prior pending applications of the applicant mentioned above and which are incorporated by reference for the sake of completeness of disclosure, if necessary.

Fig. 1 shows, in a rear cross sectional view, the application of the prior invention showing the inner surface of the shoe sole conforming to the natural contour of the foot and the thickness of the shoe sole remaining constant in the frontal plane, so that the

outer surface coincides with the theoretically ideal stability plane.

Fig. 2 shows a fully contoured shoe sole design of the applicant's prior invention that follows the natural contour of all of the foot, the bottom as well as the sides, while retaining a constant shoe sole thickness in the frontal plane.

The fully contoured shoe sole assumes that the resulting slightly rounded bottom when unloaded will deform under load and flatten just as the human foot bottom is slightly rounded unloaded but flattens under load; therefore, shoe sole material must be of such composition as to allow the natural deformation following that of the foot. The design applies particularly to the heel, but to the rest of the shoe sole as well. By providing the closest match to the natural shape of the foot, the fully contoured design allows the foot to function as naturally as possible. Under load, Fig. 2 would deform by flattening to look essentially like Fig. 1. Seen in this light, the naturally contoured side design in Fig. 1 is a more conventional, conservative design that is a special case of the more general fully contoured design in Fig. 2, which is the closest to the natural form of the foot, but the least conventional. The amount of deformation flattening used in the Fig. 1 design, which obviously varies under different loads, is not an essential element of the applicant's invention.

Figs. 1 and 2 both show in frontal plane cross sections the essential concept underlying this invention, the theoretically ideal stability plane, which is also theoretically ideal for efficient natural motion of all kinds, including running, jogging or walking. Fig. 2 shows the most general case of the invention, the fully contoured design, which conforms to the natural shape of the unloaded foot. For any given individual, the theoretically ideal stability plane 51 is determined, first, by the desired shoe sole thickness(es) in a frontal plane

cross section, and, second, by the natural shape of the individual's foot surface 29.

For the special case shown in Fig. 1, the theoretically ideal stability plane for any particular individual (or size average of individuals) is determined, first, by the given frontal plane cross section shoe sole thickness(es); second, by the natural shape of the individual's foot; and, third, by the frontal plane cross section width of the individual's load-bearing footprint 30b, which is defined as the upper surface of the shoe sole that is in physical contact with and supports the human foot sole.

The theoretically ideal stability plane for the special case is composed conceptually of two parts. Shown in Fig. 1, the first part is a line segment 31b of equal length and parallel to line 30b at a constant distance(s) equal to shoe sole thickness. This corresponds to a conventional shoe sole directly underneath the human foot, and also corresponds to the flattened portion of the bottom of the load-bearing foot sole 28b. The second part is the naturally contoured stability side outer edge 31a located at each side of the first part, line segment 31b. Each point on the contoured side outer edge 31a is located at a distance which is exactly shoe sole thickness(es) from the closest point on the contoured side inner edge 30a.

In summary, the theoretically ideal stability plane is the essence of this invention because it is used to determine a geometrically precise bottom contour of the shoe sole based on a top contour that conforms to the contour of the foot. This invention specifically claims the exactly determined geometric relationship just described.

It can be stated unequivocally that any shoe sole contour, even of similar contour, that exceeds the theoretically ideal stability plane will restrict natural foot motion, while any less than that plane will degrade natural stability, in direct proportion to the amount of

the deviation. The theoretical ideal was taken to be that which is closest to natural.

Fig. 3 illustrates in frontal plane cross section another variation of the applicant's prior invention that uses stabilizing quadrants 26 at the outer edge of a conventional shoe sole 28b illustrated generally at the reference numeral 28. The stabilizing quadrants would be abbreviated in actual embodiments as shown in Figs. 3B and 3D.

Fig. 4 shows a conventional athletic shoe in cross section at the heel, with a conventional shoe sole 22 having essentially flat upper and lower surfaces and having both a strong heel counter 141 and an additional reinforcement in the form of motion control device 142.

Fig. 5 illustrates the same conventional running shoe shown in Fig. 4, but shown when that shoe is tilted outward laterally in 20 degrees of inversion motion at the normal natural limit of such motion in the barefoot. Fig. 5 demonstrates that the conventional shoe sole 22 functions as an essentially rigid structure in the frontal plane, maintaining its essentially flat, rectangular shape when tilted and supported only by its outside, lower corner edge 23, about which it moves in rotation on the ground 43 when tilted. Both heel counter 141 and motion control device 142 significantly enhance and increase the rigidity of the shoe sole 22 when tilted. All three structures serve to restrict and resist deformation of the shoe sole 22 under normal loads, including standing, walking and running. Indeed, the structural rigidity of most conventional street shoe materials alone, especially in the critical heel area, is usually enough to effectively prevent deformation.

Fig. 6 shows a similar heel cross section of a barefoot tilted outward laterally at the normal 20 degree inversion maximum. In marked contrast to Fig. 5, Fig. 6 demonstrates that such normal tilting motion in the barefoot is accompanied by a very substantial amount of flattening deformation of the human foot sole, which has a

pronounced rounded contour when unloaded, as will be seen in foot sole surface 29 later in Fig. 11.

Fig. 6 shows that in the critical heel area the barefoot maintains almost as great a flattened area of contact with the ground when tilted at its 20 degree maximum as when upright, as seen later in Fig. 7. In complete contrast, Figs. 4 and 5 indicate clearly that the conventional shoe sole changes in an instant from an area of contact with the ground 43 substantially greater than that of the barefoot, as much as 100 percent more when measuring in roughly the frontal plane, to a very narrow edge only in contact with the ground, an area of contact many times less than the barefoot. The unavoidable consequence of that difference is that the conventional shoe sole is inherently unstable and interrupts natural foot and ankle motion, creating a high and unnatural level of injuries, traumatic ankle sprains in particular and a multitude of chronic overuse injuries.

This critical stability difference between a barefoot and a conventional shoe has been dramatically demonstrated in the applicant's new and original ankle sprain simulation test described in detail in the applicant's earlier U.S. patent application 07/400,714, filed on August 30, 1989 and was referred to also in both of his earlier applications previously noted here.

Fig. 7A shows, in frontal plane cross section at the heel, the applicant's new invention, the most clearcut benefit of which is to provide inherent stability similar to the barefoot in the ankle sprain simulation test mentioned above.

It does so by providing conventional shoe soles with sufficient flexibility to deform in parallel with the natural deformation of the foot. Fig. 7A indicates a conventional shoe sole into which have been introduced deformation slits 151, also called sipes, which are located optimally in the vertical plane and on the long axis of the shoe sole, or roughly in the sagittal plane, assuming the shoe is oriented straight ahead.

The deformation slits 151 can vary in number beginning with one, since even a single deformation slit offers improvement over an unmodified shoe sole, though obviously the more slits are used, the more closely can the surface of the shoe sole coincide naturally with the surface of the sole of the foot and deform in parallel with it. The space between slits can vary, regularly or irregularly or randomly. The deformation slits 151 can be evenly spaced, as shown, or at uneven intervals or at unsymmetrical intervals. The optimal orientation of the deformation slits 151 is coinciding with the vertical plane, but they can also be located at an angle to that plane.

The depth of the deformation slits 151 can vary. The greater the depth, the more flexibility is provided. Optimally, the slit depth should be deep enough to penetrate most but not all of the shoe sole, starting from the bottom surface 31, as shown in Fig. 7A and in Fig. 7B, a section of the shoe sole.

Fig. 7B shows the simplest technique of cutting slits into existing conventional shoe sole designs.

Near the bottom surface they can be beveled, as shown in Fig. 7C, also a section of the shoe sole. The size and angle of the beveled surface can vary, though 45 degrees is probably optimal.

The deformation slits can be enlarged to channels 151, also known as sipes, or separate removed sections from the bottom of the shoe sole, as shown in Fig. 7D, again a section of the shoe sole. Such channels 151 would typically be used optimally with the injection molding of shoe soles, since they could be cast at the same time as the shoe sole itself in one step. The size of the channels 151 can vary, from only slight enlargements of slits to much larger. They can be patterned in any way, including regular or irregular or random and can be defined by straight, curved, or irregular lines.

The deformation slits 151 can penetrate completely through the shoe sole, as shown in Fig. 7E, the

final shoe sole section shown, as long as they are firmly attached to a flexible layer 123 of cloth, of woven or compressed fibers that possess good strength, flexibility and durability characteristics, like nylon or kevlar or leather. This concept was introduced in Fig. 28 of pending U.S. application No. 07/239,667. The layer 123 can be pre-attached to the shoe sole before assembly with the shoe upper, or the shoe upper can provide suitable cloth in the case of a slip-lasted shoe. In a board-lasted shoe, the conventional paper fiber board would not be very satisfactory either in terms of flexibility or durability under repeated flexion and would preferably be upgraded to a flexible and durable board made of woven or compressed fiber, as described above, impregnated with a flexible binding material if necessary.

The construction of deformation slits shown in Fig. 7E provides the maximum amount of deformation flexibility. The deformation slit modifications shown in Figs. 7C and 7D can also be applied to the Fig. 7E approach.

A key element in the applicant's invention is the absence of either a conventional rigid heel counter or conventional rigid motion control devices, both of which significantly reduce flexibility in the frontal plane, as noted earlier in Fig. 5.

Finally, it is another advantage of the invention to provide flexibility to a shoe sole even when the material of which it is composed is relatively firm to provide good support; without the invention, both firmness and flexibility would continue to be mutually exclusive and could not coexist in the same shoe sole.

Fig. 8 shows the clearcut advantage of using the deformation slits 151. With the substitution of flexibility for rigidity in the frontal plane, the shoe sole can duplicate virtually identically the natural deformation of the human foot, even when tilted to the limit of its normal range, as shown before in Fig. 6. The natural deformation capability of the shoe sole pro-

vided by the applicant's invention shown in Fig. 8 is in complete contrast to the conventional rigid shoe sole shown in Fig. 5, which cannot deform naturally and has virtually no flexibility in the frontal plane.

Because the applicant's design allows the deformation of a modified conventional shoe sole to parallel closely the natural deformation of the barefoot, it maintains the natural stability and natural, uninterrupted motion of the barefoot throughout its normal range of sideways pronation and supination motion.

Indeed, a key feature of the applicant's invention is that it provides a means to modify existing shoe soles to allow them to deform so easily, with so little physical resistance, that the natural motion of the foot is not disrupted as it deforms naturally. This surprising result is possible even though the flat, roughly rectangular shape of the conventional shoe sole is retained and continues to exist except when it is deformed, however easily.

Fig. 9 shows, in portions of frontal plane cross sections at the heel, several forms for sides that can be attached to the sides of the conventional flat plane shoe sole, in accordance with the applicant's pending U.S. applications.

Fig. 9A illustrates the applicant's new invention incorporated with his previously referenced quadrant sided invention pending in U.S. application No. 07/219,387. The applicant's new design for deformation slits is applied to the sole portion 27 in Figs. 3 and 4 of the earlier application, to which are added a portion of quadrant stability side 26, the outer surface of which lies along a theoretically ideal stability plane 51.

Fig. 9B shows the new deformation slit invention applied to the applicant's naturally contoured side invention, pending in U.S. application No. 07/239,667. The applicant's deformation slit design is applied to the sole portion 28b in Fig. 4B, 4C, and 4D of the earlier application, to which are added a portion of a naturally

contoured side 28a, the outer surface of which lies along a theoretically ideal stability plane 51.

Fig. 9B also illustrates the use of deformation slits 152 aligned, roughly speaking, in the horizontal plane, though these planes are bent up, paralleling the sides of the foot and paralleling the theoretically ideal stability plane 51. The purpose of the deformation slits 152 is to facilitate the flattening of the naturally contoured side portion 28b, so that it can more easily follow the natural deformation of the wearer's foot in natural pronation and supination, no matter how extreme. The deformation slits 152, as shown in Fig. 9B would, in effect, coincide with the lamination boundaries of an evenly spaced, three layer shoe sole, even though that point is only conceptual and they would preferably be of injection molding shoe sole construction in order to hold the contour better.

The function of deformation slits 152 is to allow the layers to slide horizontally relative to each other, to ease deformation, rather than to open up an angular gap as deformation slits or channels 151 do functionally. Consequently, deformation slits 152 would not be glued together, just as deformation slits 152 are not, though, in contrast, deformation slits 152 could be glued loosely together with a very elastic, flexible glue that allows sufficient relative sliding motion, whereas it is not anticipated, though possible, that a glue or other deforming material of satisfactory consistency could be used to join deformation slits 151.

Optimally, deformation slits 152 would parallel the theoretically ideal stability plane 51, but could be at an angle thereto or irregular rather than a curved plane or flat to reduce construction difficulty and therefore cost of cutting when the sides have already been cast.

The deformation slits 152 approach can be used by themselves or in conjunction with the shoe sole con-

struction and natural deformation outlined in Fig. 9 of pending U.S. application No. 07/400,714.

The number of deformation slits 152 can vary like deformation slits 151 from one to any practical number and their depth can vary throughout the contoured side portion 28b. It is also possible, though not shown, for the deformation slits 152 to originate from an inner gap between shoe sole sections 28a and 28b, and end somewhat before the outside edge 53a of the contoured side 28b.

Fig. 9C and 9D show that the applicant's new invention can also specifically be applied to his earlier invention of stability sides abbreviated to essential support and propulsion elements. In Fig. 9C, a simple portion of a heel essential support element 95 forms a stability side when added to a conventional shoe sole portion modified with deformation slits and with the sharp edge corner 23 slightly contoured. As a result, when the foot is tilted out in a 20 degree inversion as shown in Fig. 9D, the foot sole side is supported by a stability side 95 that conforms to the theoretically ideal stability plane 51, at the base and lateral tuberosity of the calcaneus, the heads of the first and fifth metatarsals, and the base of the fifth metatarsal, as well as the first distal phalange.

Fig. 10 shows, again in a heel cross section, that the applicant's deformation slit invention can be applied to a conventional flat, roughly rectangular shoe sole in such a way as to transform it into a fully contoured sole like that illustrated in Fig. 2, which is contoured underneath the foot as well as on its sides. The new invention is the same as that outlined in Fig. 7, except that the shoe uppers attach to the very edge of the upper surface of the shoe sole, instead of an interior portion like Fig. 7, and the outside edge of the shoe sole is aligned in parallel to the deformation slits 151. As shown superimposed on the outline of the wearer's heel before the shoe is put on, the shoe sole

and upper do not match the outer surface of the human foot 29 as constructed; it matches the foot's shape only when put on the wearer.

Fig. 11 shows that, when the shoe shown in Fig, 10 is on the wearer's foot, the extreme flexibility of its sole, created both by the deformation slits and by the outermost edge location of the shoe supper attachment to the shoe sole upper surface, allows the inner surface 30 of the shoe sole to follow very closely the natural contour of the surface 29 of the wearer's foot, including the bottom. It does so as if the shoe sole were custom made for each individual wearer within a standard size grouping; and the outer surface of the shoe sole will coincide with the theoretically ideal stability plane 51.

Fig. 12A shows in similar cross section the deformation slit design illustrated in Fig. 7E, where the slit extends from the bottom surface of the shoe sole through to the top surface, which is connected by a fabric layer 123, providing maximum flexibility for the deformation slit invention.

Fig. 12B is the same shoe sole construction as Fig. 12 A, but in a 10 degree outward inversion, near the typical normal limit of running motion, illustrating how the design follows the routine supination deformation of the barefoot. Fig. 12B also reasonably approximates the normal limit of barefoot pronation of the opposite foot during running.

Note that the shoe sole naturally supports only the flattened portion of the load-bearing wearer's foot. If the load on the foot is increased, both the wearer's foot sole and the shoe sole would flatten more, in a direct mutual parallel.

The functioning of the shoe sole construction shown in Fig. 12B can be understood by considering the analogous situation of tank or bulldozer treads viewed from the side of the vehicle. If the vehicle rocks back and forth on its treads, a constantly wide flat section is always in contact with the ground, even though the

treads lift off the ground at either contoured end. Similarly, Fig. 12B shows a shoe sole construction that, when rolled from side to side in natural pronation or supination, always maintains roughly the same constantly large flat and stable base of contact with the ground as does the wearer's foot.

Figs. 13A through 13D show bottom views of typical conventional show soles with preferred vertical plane deformation slit patterns. All such patterns can exist alone or be superimposed over tread or cleat patterns; they can also coincide with tread or cleat patterns, in which case the most effective approach would likely be to mold in channels as the tread or cleats are cast, rather than cut slits.

Fig. 13A shows a grouping of deformation slits 151 oriented in the horizontal plane roughly along the long axis of the shoe sole. Flexibility between the heel and the base of the fifth metatarsal and long arch is provided by a flexibility slit 113, as shown in Fig. 28 of pending U.S. application No. 07/239,667 and in Fig. 11 of pending U.S. application No. 07/400,714.

Fig. 13B show deformation slits like those in Fig. 13A, except that the two outermost deformation slits are joined by a curved slit paralleling the outer edge 153 of the shoe sole 28 at the heel and the frontal plane flexibility slit 113 stops at both aforementioned slits 151 instead of intersecting them. As a result, all of the slits would remain interior to the outer edge 153 of the shoe sole and therefore none would be observable when the shoe is one the ground in its normal position, thus improving the conventional appearance of the shoe sole in the heel area, which would be important in a formal and traditional street or dress shoe. A key functional advantage of this approach is that the shoe sole can follow the natural deformation of the wearer's heel at the heel-strike phase of walking and running, and that it can do so in all vertical planes along the outer portion of the shoe sole, including the heel area, not just in

the frontal plane. The Fig. 13B approach can be applied in combination with patterns shown in other figures here and in other patterns not shown.

Fig. 13C show deformation slits 151 that are, in the heel area only, aligned with the approximately 25 degree axis of the subtalar joint. They are separated from the more conventionally aligned deformation slits of the instep area by flexibility slit 113. Other deformation slits or channels can be oriented along the joint axes of other essential support elements.

Fig. 13D shows that intersecting regular patterns of deformation slits 151, the 90 degree squares shown being among the simplest, can be used to provide easy deformation in more than one plane and in more than just the heel edge area shown in Fig. 13 B. The spacing between slits or channels can vary as before in Fig. 7A. The deformation slits or channels 151 can be straight as shown or in the small parallel wave pattern common in boat shoes, with the waves exactly in phase or exactly out of phase or in between; they can be irregularly curved or irregularly jagged; the key point is that to provide optimal deformation effectiveness, the axes of each group of deformation slits should be parallel.

Certainly, any number and any pattern of deformation slits 151 offer at least a degree of improvement over otherwise almost completely rigid conventional shoe soles, even a totally random pattern or only a single slit.

The fundamental point that has been overlooked in shoe design until now is that the shoe sole must be able to flex just as easily as the foot does <u>in all planes of motion</u> in order not to disrupt the foot's natural biomechanical function. Until now it has been generally accepted that the shoe sole can be correctly considered as functionally a part of the ground, with no more need of flexibility than has the ground, except for forefoot flexion on the ground, which is so obvious it

cannot be ignored completely, even though sometimes it is.

Fig. 13D, though showing a heel section, may in fact be the most effective way to provide multi-planar flexibility in the forefoot. The earlier approach of doing so, discussed in Fig. 28 of U.S. application No. 07/239,667 may not be most optimal because of practical difficulties in aligning any particular individual's essential forefoot support structure, that is, each of his metatarsal heads and distal phalanges, with corresponding support structures in the shoe sole. Consequently, simply providing adequate multi-planar flexibility at every discrete functional point in the forefoot may be the most practical and effective approach, since individual alignment would no longer be a factor. Both approaches can be used together.

Fig. 14 shows a sample of intersecting patterns of straight line deformation slits 151. Fig. 14A shows simple 90 degree intersection, resulting in squares and providing optimal flexibility in two vertical planes. The angle of intersection of the straight lines, which can be curved or otherwise not straight, can vary, as can the distance between deformation slits, which can be even, or uneven but a periodically repeating sequence, or erratically spaced. The darkened squares indicate that shoe sole portions can be remove to provide tread or cleat-like shoe soles; this can be done regularly, as shown, or irregularly.

Fig. 14B shows three groups of parallel straight line deformation slits 151 intersecting at 60 degrees, resulting in an equilateral triangle pattern and providing optimal flexibility in three planes. The same nearly unlimited range of variation described in Fig. 14A and in Fig. 13 applies to this figure as well.

The Fig. 14B pattern would be particularly useful in the forefoot area to provide superior flexibility while avoiding the potential alignment difficulties men-

tioned at the end of Fig. 13D. The darkened triangles represent removed portions to provide tread or cleats.

Fig. 14C shows four groups of parallel straight line deformation slits 151 intersecting at 45 degrees, resulting in a right triangle pattern and providing optimal flexibility in four planes. The same unlimited range of variations described in Figs. 14A and 14B also apply to this figure. Particularly for complex patterns like Fig. 14C, but also for any multi-planar pattern of deformation slits, the depth of one group of deformation slits can be greater than that of another group, where flexibility in one plane, like the frontal plane in the heel area, is considered more critical than in another plane; the variation of the depth of the deformation slits between groups or singly can be in any pattern or can even be random, with varying levels of effectiveness.

Fig. 15 shows the same deformation slit 151 concept described heretofore applied to just the structure of shoe bottom soles. The purpose of doing so is again to allow natural flattening deformation like the sole of the barefoot and unlike the too rigid bottom soles of existing shoes. The bottom soles of existing shoes, especially in the heel area, are relatively hard and thick to provide good wear characteristics, but because of that hardness and thickness, do not deform easily.

With existing designs, the only way to obtain shoe sole flexibility to disperse widely small support areas (like waffles or cleats) so that the relatively thin areas in between can provide flexibility; however, that approach leaves only a relatively small surface area on the bottom surface of the bottom sole, limiting its wear substantially.

To provide both hard bottoms with almost no limit on surface area other than that of the bottom surface of the bottom sole (i.e., coinciding with the theoretically ideal stability plane) <u>and</u> natural flexibility to flatten like the barefoot, the new shoe bottom sole

design is siped (i.e., provided with slits or channels through most on the bottom sole layer) like conventional boat shoes, but for the purpose of providing flexibility rather than traction (boat shoes have relatively thin forefoot soles requiring no flexibility enhancement) and along more than just the single axis used conventionally. The sipes can be both, as conventionally, in straight lines or in regular waving parallel lines (oriented around a straight line axis), as is also seen.

Figs. 15A shows a close-up cross section of such a design for bottom sole, indicating that the key to flexibility is that the bottom sole is continuous and unsiped for only a very narrow thickness relative to the overall thickness of the bottom sole. Such a design inherently provides good traction at the sides since there is space between the sections along the bottom surface of the shoe sole where it bends to conform to the contoured sides of the foot. It is also possible to do away with the thin continuous portion of the bottom sole, which serves to position the discontinuous sections below, and either affix the lower sections directly to the midsole or to an intermediary flexible surface of fabric, so long as those lower sections are wide enough relative to their thickness to remain stably fixed to the midsole. Flexibility can also be achieved by embedding hard sections of bottom sole in a softer material between those sections.

Fig. 15B shows a square design that allows motion on two axes perpendicular to each other, though the pattern could also be diamond shaped with the axes at any other angle to each other from 0 to 90 degrees (not shown).

Fig. 15C shows an equilateral triangle design that allows motion on three axes, each 60 degrees from the others, though the pattern could also be other isosceles triangles with axes at other angles to each other.

Fig. 15D shows an isosceles right triangle design that allows motion on four axes, each 45 degrees from the others, though the pattern could also be right triangles with axes at other angles to each other. Additional axes are theoretically possible, but less practical. All of these multi-axes siped designs provide flexibility for the maximum possible surface area of bottom sole for maximum wear characteristics. The surface of the design would coincide with the theoretically ideal stability plane and would be superimposed over the tread pattern; that is, large cleat-like areas which are not now flexible, would become so because the sipe pattern would be molded or cut into them.

The shaded sections of Figs. 15B-15D indicate where sections of the discontinuous bottom sole can be removed to provide more cleat-like traction on irregular ground conditions.

Fig. 15E shows a honeycomb pattern with flexibility on three axes.

Fig. 15F shows bottom sole cross sections that have grooves cut on the bottom surface of the bottom sole along the siped flexibility axes in order to provide greater traction, though less wear.

Fig. 15G shows channels cut in the bottom sole along the siped flexibility axes to provide for even greater flexibility and traction, though less wear.

Finally, it should be noted that the sipes, especially in the form of slits 151, can be superimposed on other tread patterns, especially those with large area sections of tread (most typical and necessary in the heel area), in order to provide flexibility through the treads, instead of flexibility being interrupted by the treads as occurs conventionally. In contrast, in existing art the tread pattern of the shoe sole determines the flexibility pattern. This new principle is a key to providing both adequate structural support and, at the same time, in the forefoot, where the tread pattern would optimally mirror the complex structure of metatarsal and

phalange heads to support them effectively, but that pattern would not provide effective flexibility because the curved structure of the support heads obstruct natural flex lines; with flexibility slits like those shown in Fig. 15D running through the forefoot treads, adequate flexibility could be provided over any natural flex lines.

The foregoing shoe designs meet the objectives of this invention as stated above. However, it will clearly be understood by those skilled in the art that the foregoing description has been made in terms of the preferred embodiments and various changes and modifications may be made without departing from the scope of the present invention which is to be defined by the appended claims.

WHAT IS CLAIMED IS:

1. A shoe construction for a shoe, such as an athletic shoe, comprising:

a conventional shoe sole with sipes such as originating in the bottom surface of said sole to provide said shoe sole with flexibility similar to that of the wearer's foot, so that said shoe sole can substantially parallel the natural flattening deformation of the wearer's foot during the normal pronation and supination motion occurring when the wearer is standing, walking, jogging, or running.

2. The shoe sole construction as set forth in claim 1, wherein said deformation slits or channels are oriented in about vertical planes that are substantially parallel to about the long axis of said shoe sole, in order to provide flexibility in the frontal plane of said shoe sole.

3. The shoe sole construction as set forth in claim 1, wherein said deformation slits or channels penetrate most of the shoe sole.

4. The shoe sole construction as set forth in claim 1, wherein said deformation slits or channels penetrate all of said shoe sole and wherein all portions of said shoe sole are fixed to an unpenetrated layer on the top surface of said shoe sole composed of a flexible and durable fabric or equivalent material.

5. The shoe sole construction as set forth in claim 1, wherein said deformation slits or channels in the heel area of said shoe sole are oriented in about vertical planes that are about parallel to the subtalar axis.

6. The shoe sole construction as set forth in claim 1, wherein groups of deformation slits or channels are oriented on different axes to provide shoe sole flexibility in more than one about vertical plane.

7. The shoe sole construction as set forth in claim 1, wherein flexible shoe uppers are affixed to said shoe sole at the outer edge of the upper surface of said shoe sole so that said shoe sole conforms to the natural contour of the wearer's foot sole, including at least portions of both the bottom and the sides.

8. The shoe sole construction as set forth in claim 1, wherein said deformation slits or channels penetrate most or all of only the bottom or outer sole layer of said shoe sole to provide flexibility.

9. The shoe sole construction as set forth in claim 1, wherein extended side portions are added at the essential support elements, which include the base and lateral tuberosity of the calcaneus, the heads of the metatarsals, the base of the fifth metatarsal, and the first distal phalange, to form a side outer sole surface that approximates the theoretically ideal stability plane and an inner surface that roughly approximates the shape of the fully pronated or supinated foot.

10. The shoe sole construction as set forth in claim 9, wherein extended side portions of said shoe sole have slits or channels originating on the edge of said side portions to provide said side portions with flexibility similar to the sides of the wearer's foot sole, so that said side portion can substantially parallel the natural flattening deformation of the wearer's foot.

11. The shoe sole construction for a shoe, such as a street or athletic shoe, comprising:

a sole having a sole portion and a contoured edge portion extending along at least a portion of said sole portion;

said sole portion including a foot support surface and defined by a thickness;

said edge portion being defined at least in part by an arc of a circular surface having a radius about equal to the thickness of said sole portion, wherein the thickness of the sole portion varies and the radius defining the arc of said edge portion correspondingly varies about directly and equally with the thickness of the sole portion, said contoured edge portion extending along at least a heel portion of said sole portion;

said sole portion having sipes such as slits or channels originating in the bottom surface of said sole portion to provide said sole portion with flexibility similar to that of the wearer's foot during normal pronation and supination motion occurring during standing, walking, jogging, or running.

12. The shoe sole construction as set forth in claim 11, wherein said deformation slits or channels are oriented in about vertical planes that are substantially parallel to about the long axis of said shoe sole, in order to provide flexibility in the frontal plane of said shoe sole.

13. The shoe sole construction as set forth in claim 11, wherein said deformation slits or channels penetrate most of the shoe sole.

14. The shoe sole construction as set forth in claim 11, wherein said deformation slits or channels penetrate all of said shoe sole and wherein all portions of said shoe sole are fixed to an unpenetrated layer on the top surface of said shoe sole composed of a flexible and durable fabric or equivalent material.

15. The shoe sole construction as set forth in claim 11, wherein said deformation slits or channels in the heel area of said shoe sole are oriented in about vertical planes that are about parallel to the subtalar axis.

16. The shoe sole construction as set forth in claim 11, wherein groups of deformation slits or channels are oriented on different axes to provide shoe sole flexibility in more than one about vertical plane.

17. The shoe sole construction as set forth in claim 11, wherein flexible shoe uppers are affixed to said shoe sole at the outer edge of the upper surface of said shoe sole so that said shoe sole conforms to the natural contour of the wearer's foot sole, including at least portions of both the bottom and the sides.

18. The shoe sole construction as set forth in claim 11, wherein said deformation slits or channels penetrate most or all of only the bottom or outer sole layer of said shoe sole to provide flexibility.

19. A shoe sole construction for a shoe, such as a street or athletic shoe, comprising:

a sole having a substantially flat sole portion including a foot support surface at least a portion of which is defined by about a load-bearing foot print, a naturally contoured side portion merging with at least a heel portion of said sole portion and conforming substantially to the shape of the associated sides of the wearer's foot, and a substantially uniform frontal plane thickness;

said thickness being defined as about the shortest distance between any point on the upper foot contacting surface of said shoe sole and the lower ground-contacting surface;

said thickness varying in about the sagittal plane and being greater in said heel portion than in the forefoot;

said thickness of said naturally contoured side portion about equaling and therefore varying substantially directly with said thickness of the sole portion in about said frontal plane;

said sole portion having sipes such as slits or channels originating in the bottom surface of said sole portion to provide said sole portion with flexibility similar to that of the wearer's foot during normal pronation and supination motion occurring during standing, walking, jogging, or running.

20. The shoe sole construction as set forth in claim 19, wherein said deformation slits or channels are oriented in about vertical planes that are substantially parallel to about the long axis of said shoe sole, in order to provide flexibility in the frontal plane of said shoe sole.

21. The shoe sole construction as set forth in claim 19, wherein said deformation slits or channels penetrate most of the shoe sole.

22. The shoe sole construction as set forth in claim 19, wherein said deformation slits or channels penetrate all of said shoe sole and wherein all portions of said shoe sole are fixed to an unpenetrated layer on the top surface of said shoe sole composed of a flexible and durable fabric or equivalent material.

23. The shoe sole construction as set forth in claim 19, wherein said deformation slits or channels in the heel area of said shoe sole are oriented in about vertical planes that are about parallel to the subtalar axis.

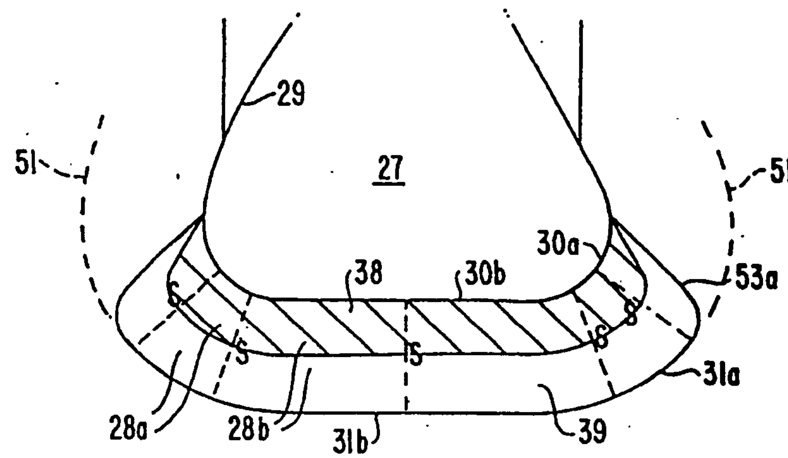
24. The shoe sole construction as set forth in claim 19, wherein groups of deformation slits or channels are oriented on different axes to provide shoe sole flexibility in more than one about vertical plane.

25. The shoe sole construction as set forth in claim 19, wherein said deformation slits or channels penetrate most or all of only the bottom or outer sole layer of said shoe sole to provide flexibility.

26. The shoe sole construction as set forth in claim 19, wherein extended side portions of said shoe sole have slits or channels originating on the edge of said side portions to provide said side portions with flexibility similar to the sides of the wearer's foot sole, so that said side portion can substantially parallel the natural flattening deformation of the wearer's foot.

27. A shoe sole construction, comprising a shoe sole having an upper foot contacting surface, a lower ground engaging surface, and an edge surface generally extending between said upper and said lower surface along a periphery generally defined by a foot print on a wearer, said sole including a plurality of sipes in the form of slits or channels lying substantially along and parallel to a long axis of said sole, said sole and said openings being structurally adapted to emulate a natural flattening deformation of a wearer's foot along the normal pronation and supination motion wherein the wearer is standing, walking, jogging or running.

FIG. 1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31b
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FIG. 2

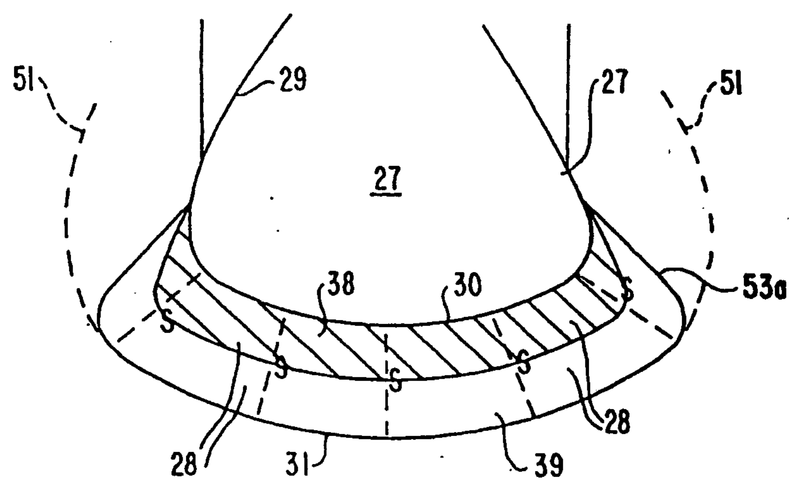
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FIG. 3A

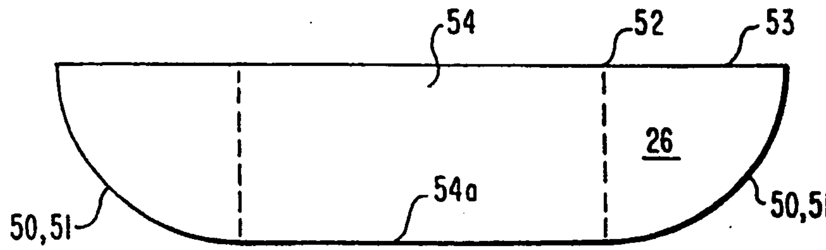


FIG. 3B

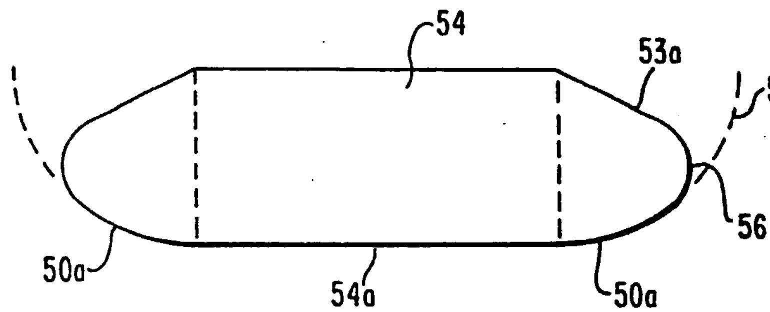


FIG. 3C

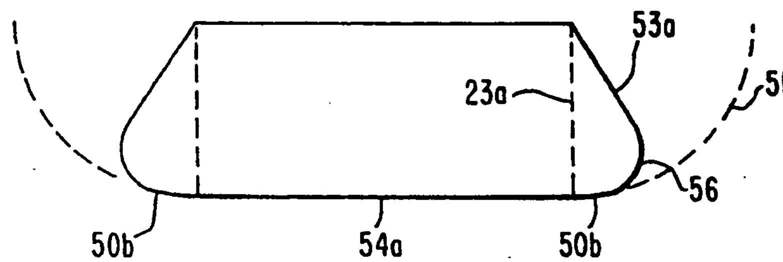
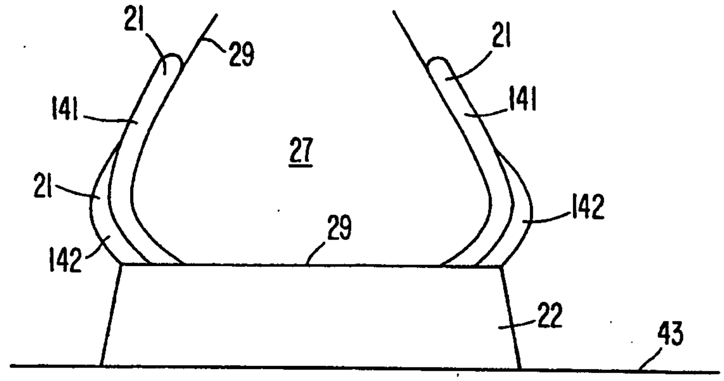


FIG. 4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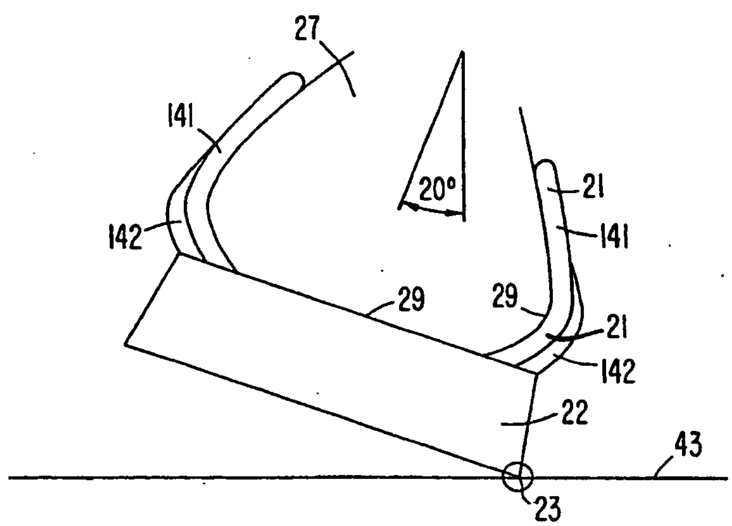
43

FIG. 5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23

FIG. 6

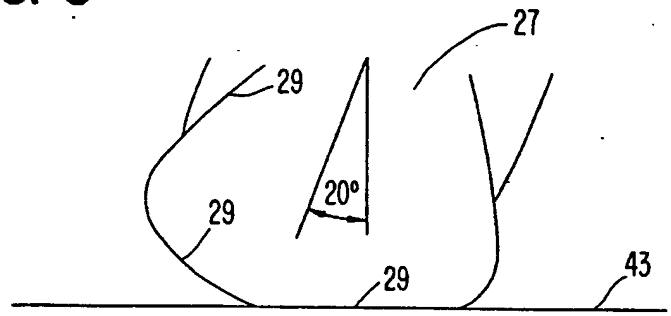


FIG. 7A

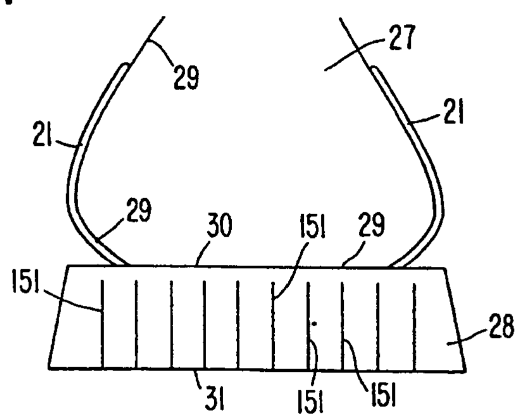


FIG. 8

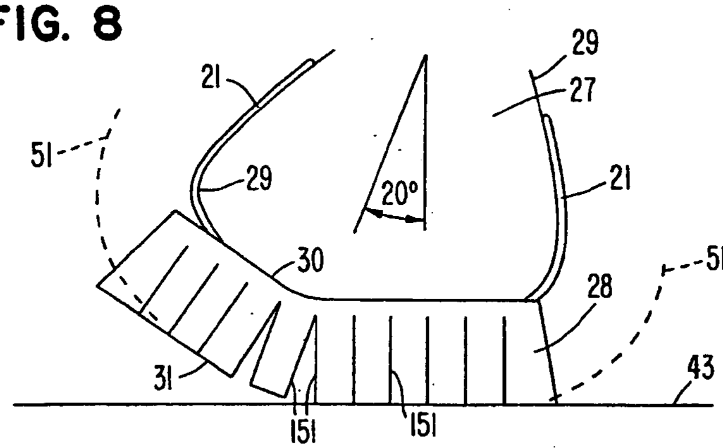


FIG. 9A

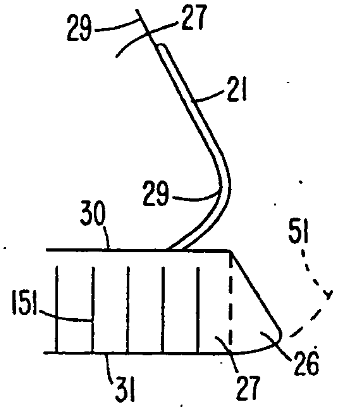


FIG. 9B

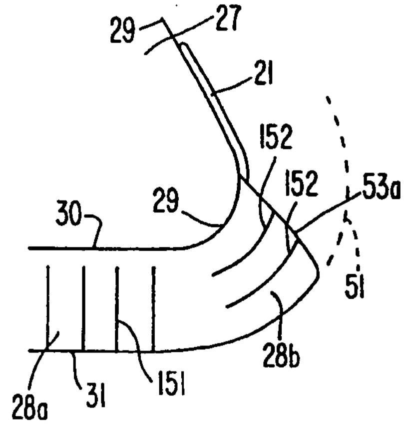


FIG. 9C

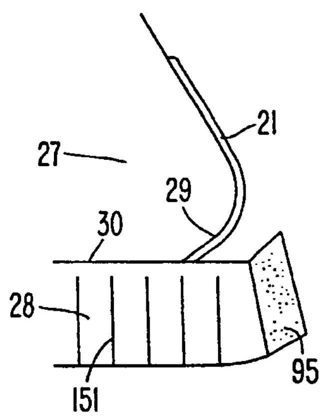


FIG. 9D

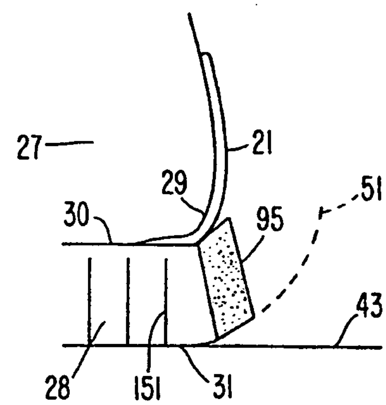


FIG. 10

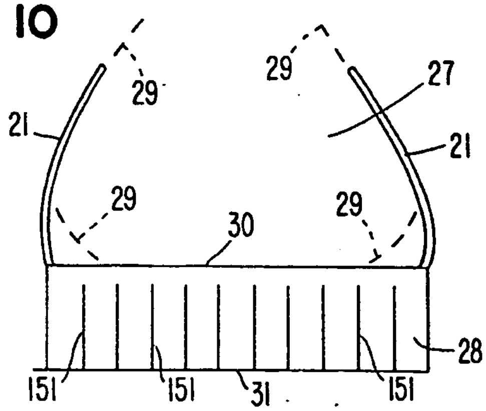


FIG. 11

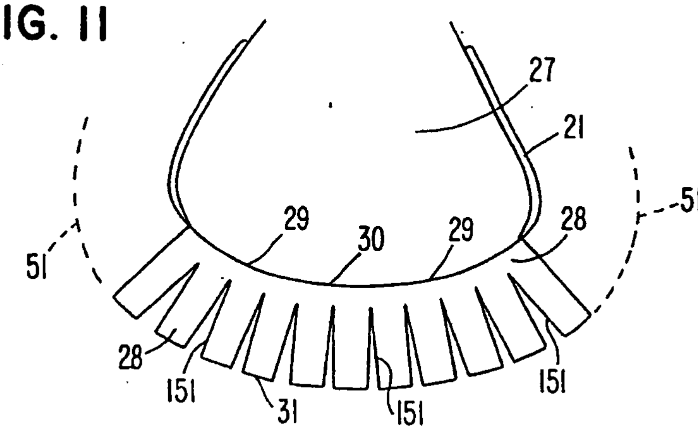


FIG. 12A

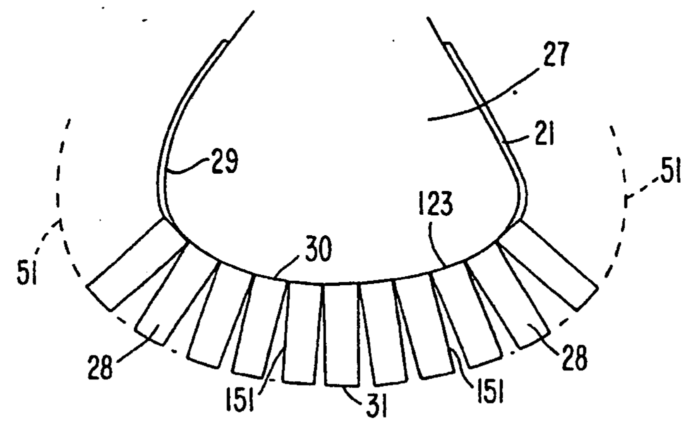


FIG. 12B

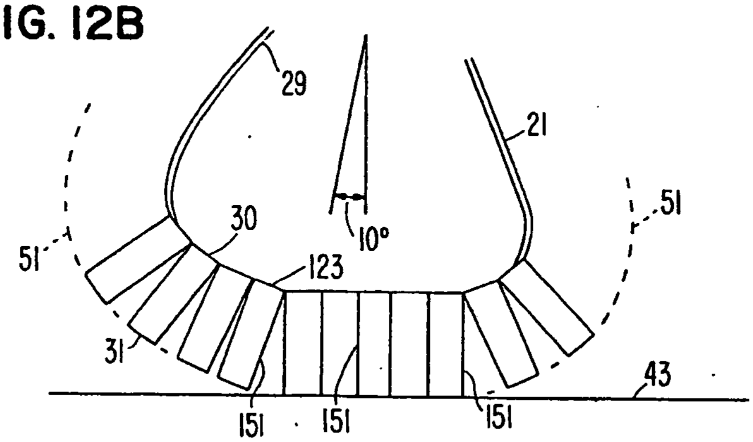


FIG. 13A

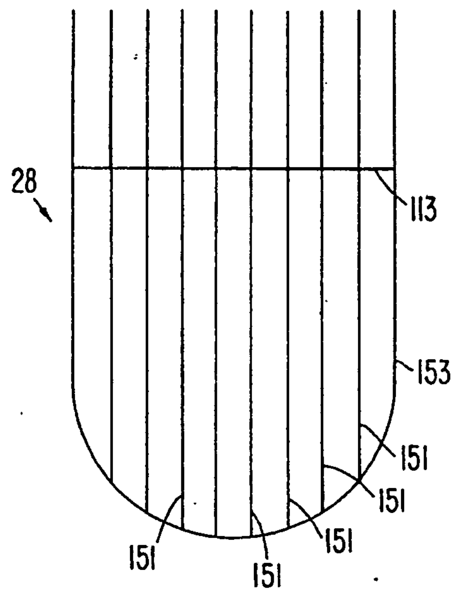


FIG. 13B

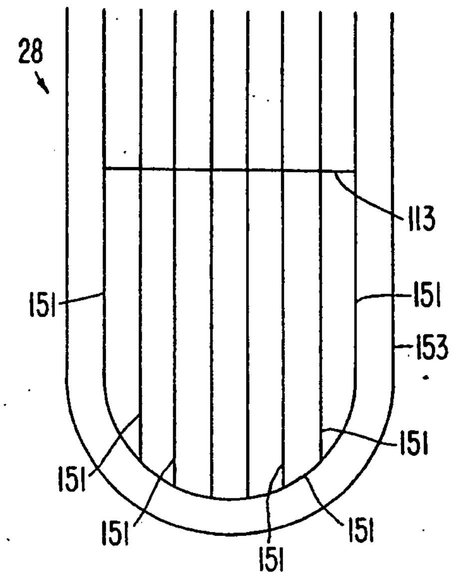


FIG. 13C

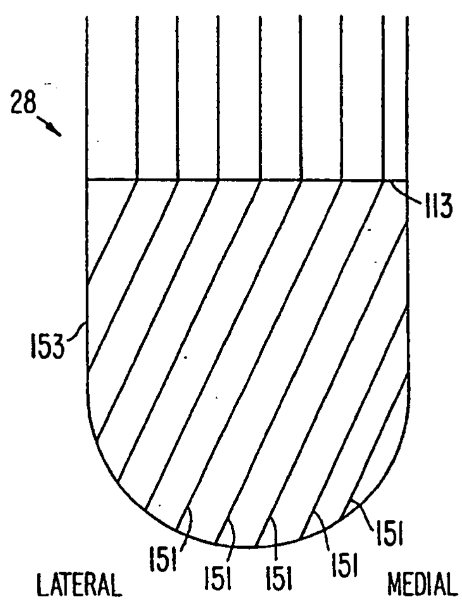


FIG. 13D

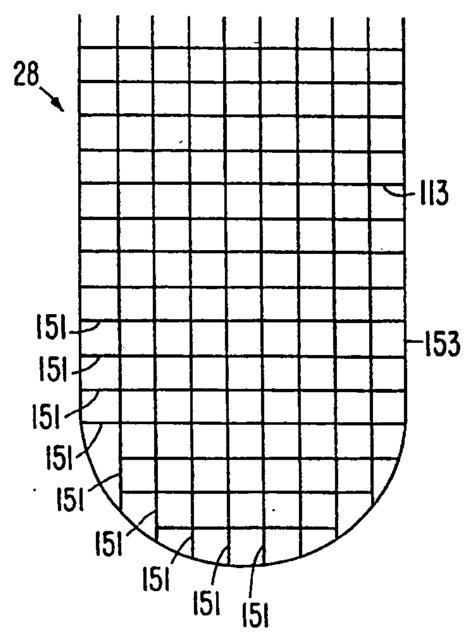


FIG. 7E

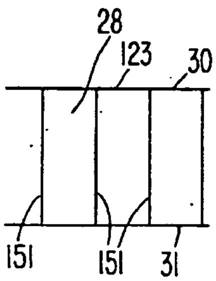


FIG. 7B

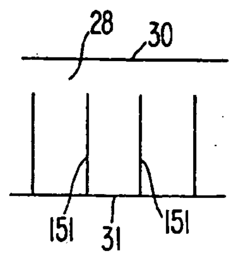


FIG. 7C

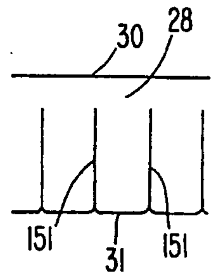


FIG. 7D

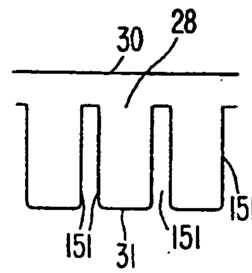


FIG. 14B

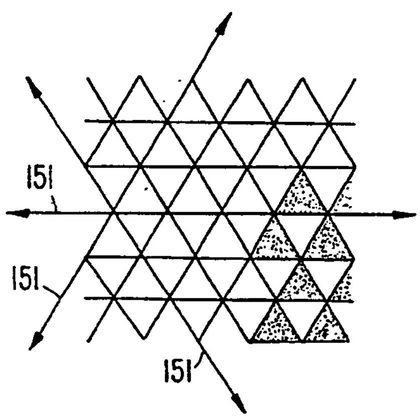


FIG. 14C

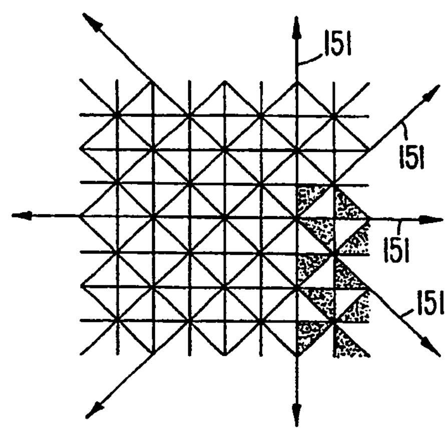


FIG. 14A

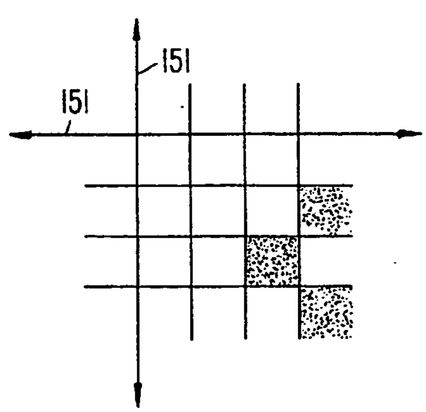


FIG. 14D

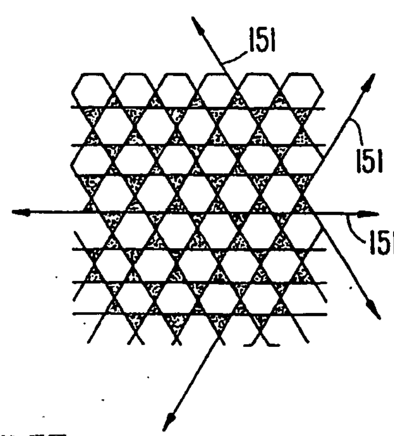


FIG. 15A

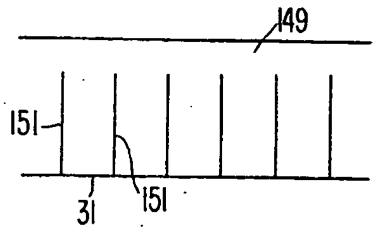


FIG. 15F

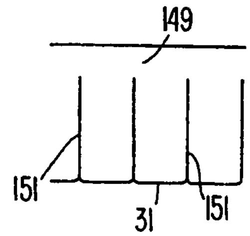


FIG. 15G

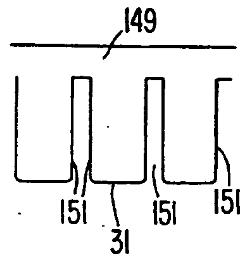


FIG. 15C

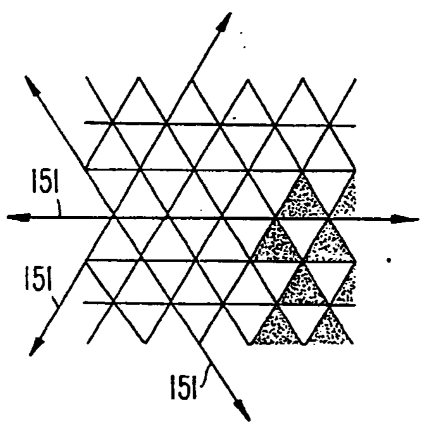


FIG. 15D

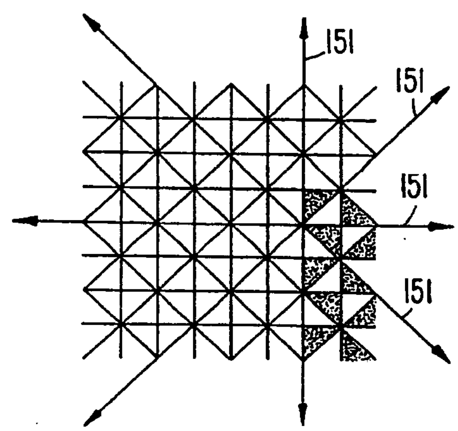


FIG. 15B

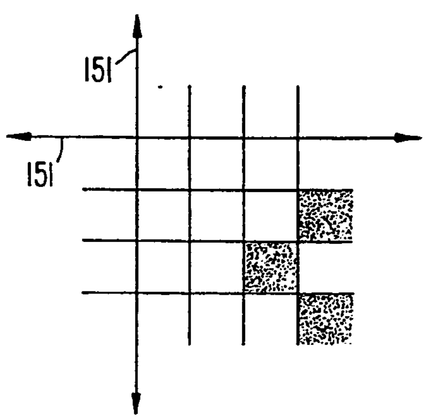
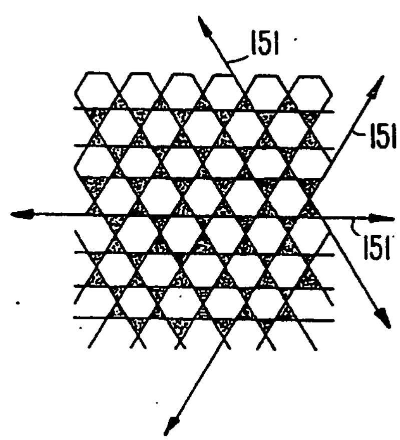


FIG. 15E



INTERNATIONAL SEARCH REPORT

International Application No PCT/US90/06028

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

INT CL (5) A43B 13/00, A43B 13/14
U.S. CL: 36/32R, 25R, 102

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	36/25R, 32R, 102,103,28,31,114

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X,Y	US, A, 500,385 HAU 27 June 1893 See entire document	1-8, 27 / 9-26
Y	US, A, 2,155,166 KRAFT 18 April 1939 See entire document.	9,11-25
Y	US, A, 4,638,577 RIGGS 27 January 1987 See entire document.	10 and 26
A	US, A, 4,777,738 GIESE ET AL. 18 October 1988	
A	US, A, 4,724,622 MILLS 16 February 1988	
A	US, A, 4,570,362 VERMONET 18 February 1986	
A	US, A, 4,059,910 BRYDEN ET AL. 29 November 1977	
A	US, A, 3,295,230 SZERENYL ET AL. 03 January 1967	
A	US, A, 2,470,200 WALLACH 17 May 1949	
A	US, A, 2,345,831 PIERSON 04 April 1944	
A	US, A, 2,206,860 SPERRY 09 July 1940	

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
06 DECEMBER 1990	12 FEB 1991
International Searching Authority [1]	**Signature of Authorized Officer** [20]
ISA/US	STEVEN N. MEYERS

Form PCT/ISA/210 (second sheet) (May 1986)

International Application No PCT/US90/06028

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A	US, A, 2,124,986 PIPES 26 July 1938	
A	US, A, 280,791 BROOKS 10 July 1883	
A	WO, A, 8303528 DEAN 27 October 1983	

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers , because they relate to subject matter [1] not required to be searched by this Authority, namely:

2. ☐ Claim numbers .... , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [1], specifically:

3. ☐ Claim numbers__________, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.